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SPECSweb Multistatic Tracking on a Truth-Blind Simulated Scenario of the MSTWG

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Abstract - *Effective fusion and tracking of multistatic active sonar contacts is challenging, due to high levels of false alarm clutter present on all sonar nodes. Such false alarms often overload the sensor-to-fusion-center communications links and fusion/tracking processes, producing too many false tracks. The Specular-Cued Surveillance Web (SPECSweb) multistatic tracker mitigates these problems through implementation of two amplitude thresholds: a high threshold used to identify the occurrence of high-strength specular detection cues for track initiation, and a low threshold for selective extraction of additional detections within retrieval snippets for track extension forward and backward in time. This approach can significantly reduce the data rate at the input to the fusion/tracking algorithm, and reduce node-to-fusion-center communication link throughput requirements. This paper provides performance results of this tracking algorithm on simulated multistatic data sets from the Multistatic Tracking Working Group (MSTWG). These included a ("truth-blind") data set for which the target truth information was not provided in advance of the time of algorithm application. The results show effective tracking performance using this approach, yielding high quality target tracks with no or few false tracks. The method is shown to have excellent potential in reducing the overloading of the communication links, the automated tracking algorithm, and the ultimately, the operator.*

Keywords: Multistatic Sonar, Multi-sensor Fusion, Tracking, Cueing, Specular, Target Strength, MSTWG

1 Introduction

Distributed multistatic active sonar networks have the potential to increase ASW performance against small, quiet, threat submarines in the harsh clutter-saturated littoral and deeper ocean environments. This improved performance comes through the expanded geometric diversity of a distributed field of sources and receivers and results in increased probability of detection, area coverage, target tracking, classification, and localization [1].

However, with the increased number of sensors in a multistatic network, come corresponding increases in the data rate, processing, communications requirements, and operator loading. Without an effective fusion of the multistatic data, the benefits of such systems will be unrealizable. Effective, robust, and automated multi-sensor data fusion and tracking algorithms become an essential part of such systems. Much progress has recently been made in this field [2-5]; however, overloading due to high false alarm rates is still a major issue. Multistatic fusion algorithms are still challenged to automatically output a sufficiently low false track/alert rate to the operator in these reverberation- and clutter-rich conditions. Communication links may not have the throughput capacity to transfer all of the associated information from the multistatic nodes to a fusion center.

A concept referred to as the "Specular-Cued Surveillance Web (SPECSweb)" is being pursued to address this data rate problem through "specular cueing", directed data retrieval, retrospective tracking, and novel fusion techniques. This approach can potentially provide a robust, automated ASW detection and tracking method, resulting in a significant reduction in false alarm rates compared to conventional multistatic fusion methods. The SPECSweb application area is ASW surveillance (not necessarily tactical) missions, not time-critical tactical ones. This paper demonstrates the potential of this cueing and fusion method in obtaining high quality tracker output with greatly reduced input/output false alarm rates and communication throughput requirements. The analysis is made using simulated data sets of multistatic sonar scenarios from the Multistatic Tracking Working Group (MSTWG) [4-5]. Performance comparisons between SPECSweb and other multistatic trackers has been reported for the NURC MSTWG simulated scenario data set [5].

Section 2 in this paper describes the SPECSweb fusion/tracking algorithm. Sections 3, 4, and 5 present the results of the algorithm to the MSTWG TNO, ARL/UT, and "truth-blind" data sets, respectively. Section 6 discusses the effect of tracker fragmentation when using an inconsistent motion model. Section 7 provides conclusions.

2 SPECSweb Algorithm Description

Detailed descriptions of the SPECSweb multistatic tracking algorithm and specular cueing approach are found in [6-7]. Only a summary of the algorithm is provided here.

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14. ABSTRACT
Effective fusion and tracking of multistatic active sonar contacts is challenging, due to high levels of false alarm clutter present on all sonar nodes. Such false alarms often overload the sensor-to-fusion-center communications links and fusion/tracking processes producing too many false tracks. The Specular-Cued Surveillance Web (SPECSweb) multistatic tracker mitigates these problems through implementation of two amplitude thresholds: a high threshold used to identify the occurrence of high-strength specular detection cues for track initiation and a low threshold for selective extraction of additional detections within retrieval snippets for track extension forward and backward in time. This approach can significantly reduce the data rate at the input to the fusion/tracking algorithm, and reduce node-to-fusioncenter communication link throughput requirements. This paper provides performance results of this tracking algorithm on simulated multistatic data sets from the Multistatic Tracking Working Group (MSTWG). These included a (?truth-blind?) data set for which the target truth information was not provided in advance of the time of algorithm application. The results show effective tracking performance using this approach, yielding high quality target tracks with no or few false tracks. The method is shown to have excellent potential in reducing the overloading of the communication links, the automated tracking algorithm, and the ultimately, the operator.

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A multistatic scenario consists of multiple, cooperative, fixed or mobile sonar sources and receivers, distributed over an operational area. Sources transmit pulsed signals with different waveform types according to a transmit cycle/schedule. Receivers collect acoustic signals, including target echoes, on arrays of hydrophones. Raw data is band-filtered, beamformed (to provide direction of arrival information), matched filtered (to the transmitted pulse), and normalized. Detection processing is performed to extract and cluster echo energy into detection contacts (true and false). In the SPECSweb concept, it is possible to embed all this processing on the receiver nodes, including the local storage of all output data. Each receiver collects the contacts corresponding to one source transmission as a single scan of "ping" data.

Multistatic processing provides the following measurements which relate to target kinematics: bistatic time-of-arrival, bearing, and bistatic range-rate (if Doppler-sensitive waveforms are used). Time-of-arrival, bearing, and source/receiver positions are used to calculate the actual contact range (from the receiver) using a non-linear transformation [2].

Each sonar node (bistatic receiver processing a unique source-waveform) self-searches each processed (and locally stored) scan for contacts which exceed a high SNR threshold setting (HTH). The HTH is identifies very strong echoes, which likely correspond to targets that are in the "specular condition". The specular geometric condition occurs when the angles from the target to the source and receiver are equal (fore and aft, or, aft and fore) from the target's beam angle (±90 from target's heading). When in the specular geometry, there is greatly increased target strength, producing increased echo energy, as indicated by various models [8] and data analyses. The HTH normally rejects most (or all) of the false alarm clutter echoes, which have a lower distribution of amplitudes than do specular target echoes (though not necessarily lower levels than non-specular target echoes). Currently, the HTH is selected using knowledge of system performance, but in the future, this parameter setting will be automated and data-adaptive.

Contacts from only FM waveforms[1] which cross the HTH are assumed to be "specular cues", and (only) these are initially sent over the communication link to the multistatic fusion center for potential track initiation, as depicted in Figure 1. Note that within a multistatic field, the occurrence of a specular geometry and a resulting specular cue may not be immediate, and therefore, there is some increased track reporting latency. The SPECSweb concept assumes that a sensor distributed sensor field may be designed to produce statistically sufficient numbers of specular occurrences to initiate tracks. It also assumes that the increased detection latency (needed to wait for specular detection opportunities to occur) is within the surveillance operation's reporting timeframe requirements. Evaluation metrics for studying the occurrence statistics of specular detection in multistatic fields have been developed [9].

In addition to a target position measurement, a specular cue will provide a target heading measurement. Targets in the specular condition have a heading which is tangential to the bistatic equi-range ellipse at the contact location. There will be an ambiguity between two heading assumptions; one clockwise and one counter-clockwise about the ellipse at this point of tangency. Once a specular cue arrives at the fusion center, two tentative reverse-time tracks are initiated, corresponding to these two headings.

Cues are mapped to an x-y position in Cartesian coordinates, and these positions with its associated error covariance are sent as snippet requests to other nodes. These nodes calculate the appropriate snippet boundary in their respective measurement spaces within which data association would be possible, according to a specified gating parameter. Any contacts found within the snippet gate, and above the standard low-threshold (LTH), are then sent over the communication link for further processing. As track estimates are obtained, they themselves are used as the cues for selective data retrieval on prior scans stored on any of the nodes. If the retrospective tracking (backtracks) satisfies the initiation criteria, the tracking process continues until a track termination criteria is met. The more likely backtrack is selected, using track-length and heading-stability criteria, and the other backtrack is discarded. Recovering track history in this fashion provides valuable contextual and track classification information.

The contacts belonging to the selected backtrack are then re-filtered in the forward-time direction, until the current time (of the initiating specular cue) is reached. With this re-filtering, the best possible track estimate at the time of the cue is obtained. At this point the track continues in the forward-time direction updating with measurements found within the retrieval snippets of future scans. Subsequently occurring specular detections update track position and heading, if they are determined to be the nearest neighbor contact in the snippet. New specular detections which are not assigned to existing tracks become new tentative tracks, and the process repeats. Current forward-direction tracks will terminate when the termination criterion is met.

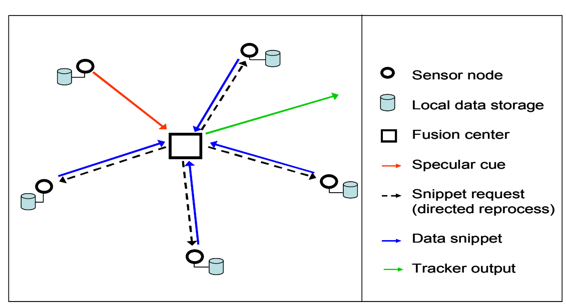

Figure 1. Diagram of the SPECSweb cueing concept.

[1] By definition, the bistatic specular condition is coincident with targets at zero-Doppler (range-rate). Zero-Doppler echoes are usually undetectable due to reverberation masking; therefore, only FM waveforms are used as specular cues.

Additional elements of the SPECSweb tracker implementation include the following:

- A logic-based track initiation (M/N) and termination (K) scheme is used.
- The target motion is modeled as 2-d *nearly constant velocity* motion model [10]. It allows for maneuvering through a process noise term, and has been shown to be effective in ASW tracking [2-3].
- Data associations between existing tracks and new measurements are made using the statistical "nearest neighbor" method. The tracks are ordered according to length, with longer tracks getting priority over shorter tracks for new association assignments. We use a 2-d or 3-d (if Doppler measurements are available) ellipsoidal association gate [11]. A method for determining the data retrieval snippet boundaries corresponding to this gating scheme is given in [7].
- A Kalman Filter [12] implementation is used with converted measurements (time-of-arrival and bearing to Cartesian X-Y) [13]. A method for de-biasing bistatic Cartesian measurements is used [3]. In the case of Doppler measurements, an Extended Kalman Filter (EKF) is implemented to handle the nonlinear bistatic range-rate measurements [14, 17].

3 SPECSweb Tracking Results MSTWG TNO Simulation Scenario

The SPECSweb tracking algorithm was applied to the MSTWG TNO simulated scenario [15]. This scenario was 3 hours in duration, with two ships, both moving east at 5 kts, as shown (in green) in Figure 2. Each ship produces monostatic (from own ship pings) and bistatic (from other-ship pings) returns. Each ship's source transmitted FM waveforms (no Doppler information) every 60 seconds over the duration of the scenario. There were a total of 720 scans of contact data from the 4 sonar nodes available for multistatic fusion. The data contained about 100 false contacts per scan, randomly distributed in measurement space, with SNR amplitudes distributed mainly between 13-20 dB. Three targets were simulated: a mobile target following a "W"-shaped trajectory at 7 kts (moving eastward), and two fixed clutter targets located near the 2nd and 3rd turns of the mobile target. None of the targets were modeled with aspect-dependent target strength; however, their SNRs were strong, with levels between 15-30 dB.

The SPECSweb tracker was run on this data set with parameters as listed in Table 1. Measurement errors were assumed with values consistent with the simulation description [15]. Within retrieval snippets, a low threshold (LTH) of 13 dB was used, which was below the minimum level used in contact formation. The results of the tracker are also shown in Figure 2, with the tracker output shown in red. There were no false tracks generated in this case, which demonstrates the power the SPECSweb tracking approach. The mobile target was tracked over the entire scenario, however, there was a fragmentation event occurring at the second turn. This fragmentation was caused by confusion with contacts from the fixed clutter target (which was tracked over about a third of the scenario, with 4 fragments). Nevertheless the tracker was able to quickly reacquire the mobile target and provides excellent tracking results. The other fixed clutter target (near the third turn) was not tracked, because of discrepancies in the simulation (cross-sensor registration errors and missing detections from one sensor). Although in this simulation there were no aspect-dependent targets, and therefore no specular detections, the tracks were successfully initiated on loud, non-specular detections present in the simulated data.

Table 1. Tracking Parameters, TNO Scenario, for SPECSweb and BASELINE trackers

Parameter	*SPECS*	*BASE*
Track initiation (M of N scans)	4/4	4/4
Track termination (K scans)	3	7
Association Gate Probability	99%	99%
Cue Threshold (HTH) in dB	27.5	N/A
Low Threshold (LTH) in dB	13	13
Maneuverability index (m^2/s^3)	0.001	0.001
Initial guess target speed (m/s)	3.6	3.6
Error initial target speed (m/s)	1.8	1.8
Error of asset positions (m)	10	10
Error of receiver bearing (deg)	2°	2°
Error of receiver timing (s)	0.01	0.01
Error of specular heading (deg)	10°	N/A

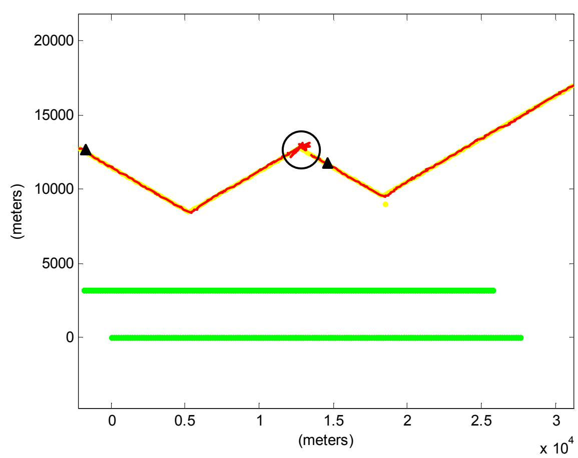

Figure 2. SPECSweb results for the TNO simulated scenario; target true trajectory (yellow); ship/asset trajectories (green); true tracks output (red); fragmentation event near fixed clutter pint (circled); initiation (black).

Figure 3 shows the results of running a BASELINE tracker, with parameters as listed in Table 1 (SPECSweb tracker but with only a single low threshold, no backtracking, etc.). It is seen that although the target is still tracked well, it results in a massively cluttered picture, with an increase in the number of false tracks (182 false tracks and 100 times the amount of data sent over communication

links). Table 2 summarizes the metrics obtained for this analysis, which shows the superior performance of the SPECSweb tracking in unloading (reduction of False Alarm Rate (FAR), communications, processing time, etc.).

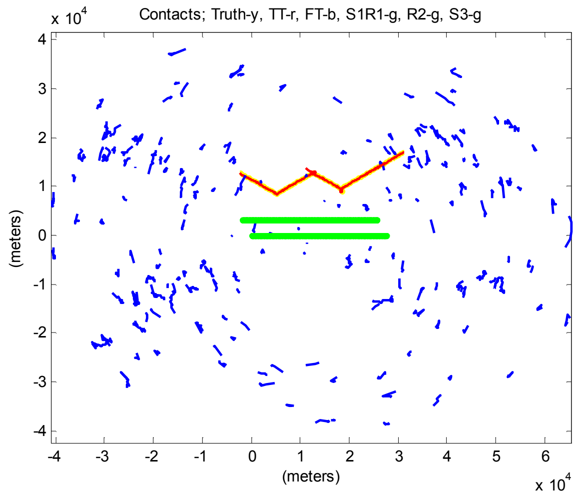

Figure 3. BASELINE tracker results for the TNO simulated scenario; ship/asset trajectories (green), target trajectory (yellow); true tracks (red); false tracks (blue).

Table 2. Performance Statistics for the TNO mobile target, SPECSweb and BASELINE

Performance Metric	*SPECS*	*BASE*
Detection latency (min)	1	1
PD - Input	0.99	0.99
PD - Output	1.0	1.0
FAR - Input (per min)	432	432
FAR - Output (per min)	0	61
Comms throughput (contacts /scenario):	2572	77760
Localization Error - Input	111 m	111 m
Localization Error - Output	127 m	3483 m
Track Purity	96%	70%
Coasts	8%	25%
Fragmentation	2	2
Fraction of real compute time	0.01	0.2

4 Tracking Results for the MSTWG ARL/UT Simulation Scenario

The SPECSweb tracking algorithm was next applied to the MSTWG ARL/UT scenario [16]. This data set is a combination of real at-sea experimental data taken in the Malta Plateau, with injected simulated targets. This scenario was 120 minutes in duration, with two fixed receivers and one fixed source (2 bistatic nodes). The source transmitted simultaneous CW and FM waveforms every 2 minutes (total of 240 scans). Two targets were injected into the data set: a fast 14 kts target heading southward past the sensors (and penetrating one of the bistatic nodes), and a slow 4 kts target moving westward, south of the sonars. The fast target was modeled with aspect dependence (as a cylinder), which resulted in multiple target-originated contacts in each scan. The slow target was modeled as a point scatterer.

The SPECSweb tracker was applied to these data, with parameters as listed in Table 3. The SPECSweb algorithm has recently been extended to handle Doppler measurements [17]; therefore, bistatic range-rate information was also utilized. Track initiation for the fast target was made on a strong specular FM echo halfway through the scenario, as the target passed by the DEMUS receivers. Track initiation for the slow target was made on a high-strength non-specular echo occurring near the beginning of the scenario. Tracking results for the fast and slow targets are shown in Figures 4 and 5, respectively. In both cases we see excellent tracking performance with a single high quality track corresponding well to the known true trajectories, and no false tracks. Figure 6 shows the results of the BASELINE tracker (fast target case only), and we see degradation of the target track. Also, there is a significant increase in the number of false tracks, which arise from acoustically reflective bottom features common to this real sonar environment. Table 4 lists the performance obtained in this analysis, which shows the effectiveness of SPECSweb in reducing false tracks and communication link loading.

Table 3. Tracking Parameters, ARL/UT Scenario

Parameter	*SPECS*	*BASE*
Track initiation (M of N scans)	1/1	3/5
Track termination (K scans)	5	5
Association Gate Probability	99%	99%
Cue Threshold (HTH) in dB	38/	N/A
Low Threshold (LTH) in dB	10	10
Maneuverability index (m^2/s^3)	0.001	0.001
Initial guess target speed (m/s)	7.2	7.2
Error initial target speed (m/s)	3.6	3.6
Error of asset positions (m)	10	10
Error of receiver bearing (deg)	8°	8°
Error of receiver timing (s)	0.01	0.01
Error of specular heading (deg)	10°	10°

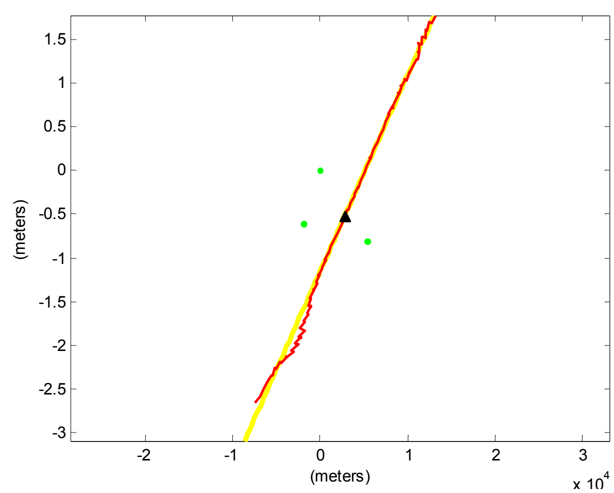

Figure 4. Results for the ARL/UT simulated fast scenario; source/receiver positions (green), target true trajectory (yellow); true tracks output (red), initiation cue (black).

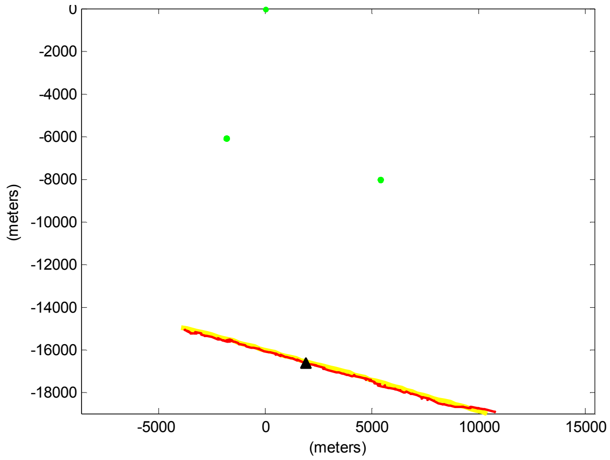

Figure 5. Results for the ARL/UT simulated slow scenario; source/receiver positions (green), target true trajectory (yellow); true tracks output (red); initiation cue (black).

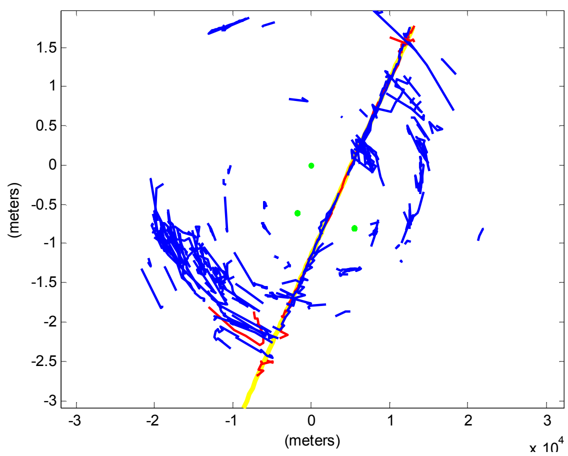

Figure 6. BASELINE tracker results for the ARL/UT simulated scenario, fast target; ship/asset true trajectories (green), target true trajectory (yellow); true tracks output (red); false tracks (blue).

Table 4. Performance metrics for the fast and slow targets with SPECSweb and the BASELINE trackers.

Performance Metric	*SPECS fast/slow*	*BASE fast/slow*
Detection latency (min)	62/50	3/4
PD - Input (%)	73/85	73/85
PD – Output (%)	92/100	92/100
FAR - Input (per min)	23/23	23/23
FAR - Output (per min)	0/0	73/67
Comms throughput (contacts /scenario):	886/399	2959
Local. Error– Input (m)	584/322	584/322
Local. Error–Output (m)	256/134	596/147
Track Purity (%)	79/94	76/94
Coasts (%)	25/10	25/10
Fragmentation	1/1	4/1
Fraction of real compute time	0.001	0.01

5 SPECSweb Tracking Results for the "Blind" Simulation Scenario

The SPECSweb tracking algorithm was next applied to the MSTWG "truth-blind" scenario. It included one known, well described reference target trajectory. It was simulated to include an unknown number of other targets for which no information was provided, a priori. The use of a data set such as this is more realistic and challenging than the case of having the truth provided. A priori. The tracking results shown here are those prior to obtaining the truth information of any additional targets. The performance analysis and metrics were obtained after subsequent revelation of the truth (number and trajectory of additional targets).

The "blind" simulated scenario was of duration 3 hours, and consisted of three sonar nodes, as shown in Figure 7. Node 1 is a bistatic configuration of a source and receiver separated by 5 km, and moving east at 5 m/s. Its source transmitted FM waveforms every 60 seconds. Node 2 was a monostatic sonar, moving 7.3 m/s with heading of about 16 degrees (relative to +x axis). It transmitted CW waveforms every 50 seconds, except for the first 5 minutes. Node 3 was a bistatic configuration with source and receiver starting at the same position and moving with similar speeds (~5 m/s), with headings of 158º and 169º. Its source transmitted alternating FM and CW waveforms every 90 seconds. The known, described reference target exhibited a sinusoidal track, with speed 7.5 m/s, and moving to the east, as shown in the figure. All targets, reference or unknown, were modeled with aspect-dependent target strength, according the BASIS model [8]. This can be seen in Figure 8, where the SNRs for the sinusoidal reference target are plotted. Node 1 (red) produces about 6 high-strength specular echoes as the target's heading oscillates. Node 3 (blue) shows one specular opportunity around the middle of the run. Node 3 (green) only transmitted CWs, and therefore does not yield specular cues.

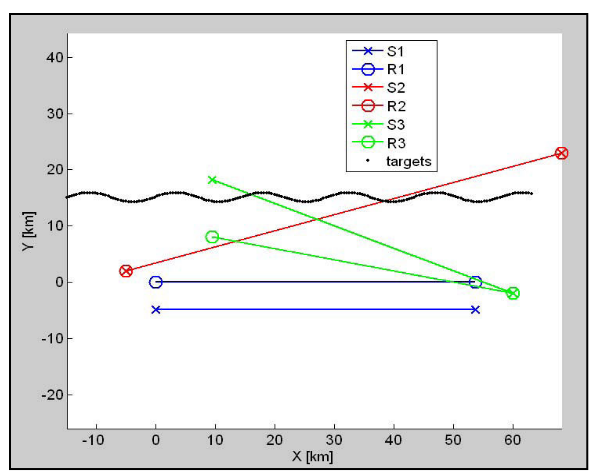

Figure 7. The MSTWG "truth-blind" simulated scenario; Node1-blue, Node2-red, Node3-green; known reference target (black).

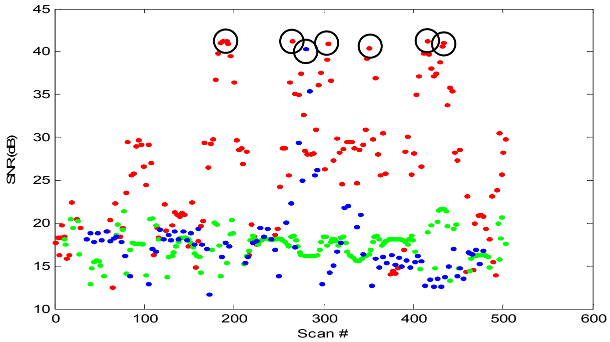

Figure 8. Sinusoidal reference target SNRs (node1–red, node2–green, node3– blue); specular detections (circled).

The SPECSweb tracker was then applied to the data set. A HTH of 25 dB was selected. This was somewhat lower than the specular events for the reference target, but was considered more conservative, with less risk to miss the other unknown targets that may be in the data set. The tracker parameters which were used are summarized in Table 5. Figure 9 shows the SPECSweb tracker output. It is seen that the sinusoidal reference target is tracked over most of its trajectory. In addition there are a number of tracks which indicate the presence of three additional targets. These were subsequently validated when scenario truth was presented at the 7th meeting of the MSTWG (January 2009). The other target trajectories are shown on the plot in yellow. Good tracking performance is seen over much of the scenario. A total of 29 tracks were output, and all of these are observed to lie closely to the four target trajectories. There are otherwise few false tracks. It is observed however, that there is a problem with tracker fragmentation, i.e., there appear to be many target-related track segments produced per target trajectory. The explanation of this effect will be discussed in a subsequent section. A summary of the targets is as follows:

- Target 1: Sinusoidal reference target (trajectory was known apriori). Three main track fragments hold the target, with seven target-related spurious fragments.
- Target 2: Constant acceleration target, with near stop and sharp turn (to the southwest). Three main track fragments hold the target, with one target-related spurious fragment
- Target 3: Constant acceleration target in x-direction (constant turn rate). One track holds the target, with three target-related spurious fragments.
- Target 4: Constant velocity target slanting to southeast. One track holds the target, with three target-related spurious fragments.

Figures 10-12, show the SNR levels for the additional targets. Observe the presence of high-strength specular echo events (circled), occurring on various nodes. The SPECSweb algorithm has initiated tracks when these have crossed the HTH.

Table 5. Tracking Parameters, "Blind" Scenario

Parameter	*value*
Track initiation (M of N scans)	3/6
Track termination (K scans)	8
Association Gate Probability	99%
Cue Threshold (HTH) in dB	25
Low Threshold (LTH) in dB	0
Maneuverability index (m^2/s^3)	0.01
Initial guess target speed (m/s)	7.25
Error initial target speed (m/s)	3.75
Error of asset positions (m)	10
Error of receiver bearing (deg)	1.5°
Error of receiver timing (s)	0.01
Error of speed of sound (m/s)	15
Error of specular heading (deg)	10°

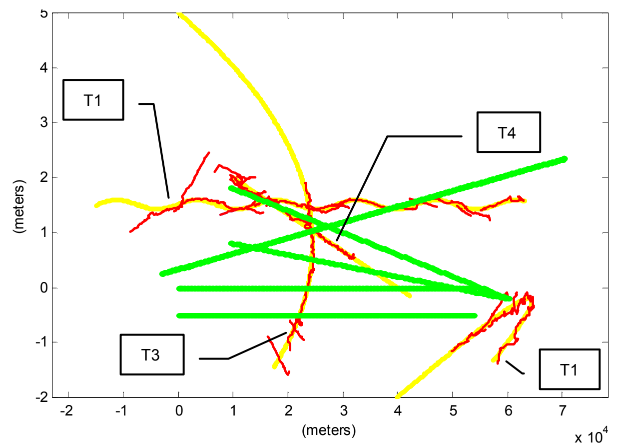

Figure 9. SPECSweb tracker output (red) for the "blind" simulated scenario with "truth" tracks shown (yellow). Asset trajectories are shown in green.

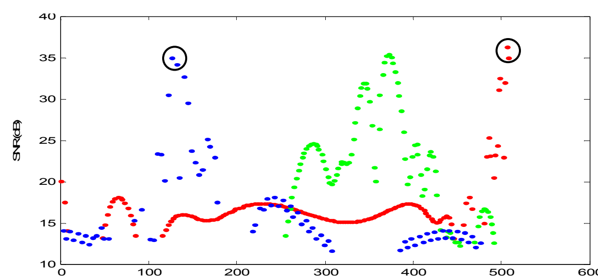

Figure 10. Target 2 SNRs, (node1–red, node 2–green, node3-blue); specular detections (circled).

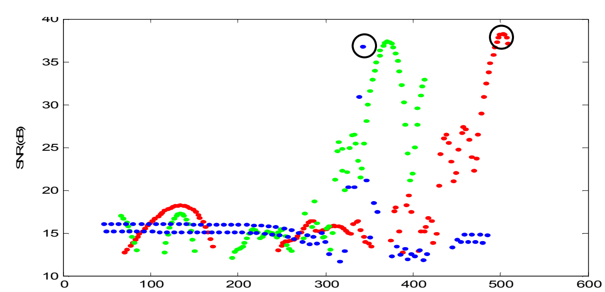

Figure 11. Target 3 SNRs, (node1–red, node 2–green, node3-blue); specular detections (circled).

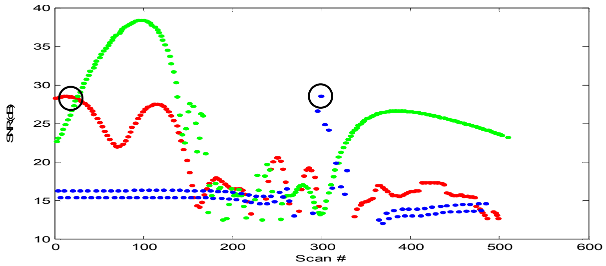

Figure 12. Target 4 SNRs, (node1–red, node 2–green, node3-blue); specular detections (circled).

The SPECSweb estimation of target speed and heading versus true target trajectory speed and heading is shown in Figures 13 and 14, respectively. We see good agreement in the mean estimation, with some variance. Tracking performance metrics for this analysis are summarized in Table 6. Targets 1 and 2 were held most of the scenario, and targets 3 and 4 were held less. All output tracks appeared to be track fragments associated to one of the four targets in the data set. Otherwise, there were no false tracks. Output localization was generally better than at the input to tracking, except for target 1. All tracks experienced higher than desired fragmentation rates.

Table 6. Performance metrics for the four targets found using the SPECSweb tracker.

Performance Metric	*Tgt1*	*Tgt2*	*Tgt3*	*Tgt4*
Detection latency (min)	31	42	167	31
PD - Input (%)	83	64	64	91
PD – Output (%)	92	84	44	64
Local. Error– Input (m)	427	668	601	412
Local. Error–Output (m)	605	478	453	384
Fragmentation	12	4	4	9
FAR - Input (per min)	318			
FAR - Output (per min)	0			
Compute time (fraction of real time)	0.01			

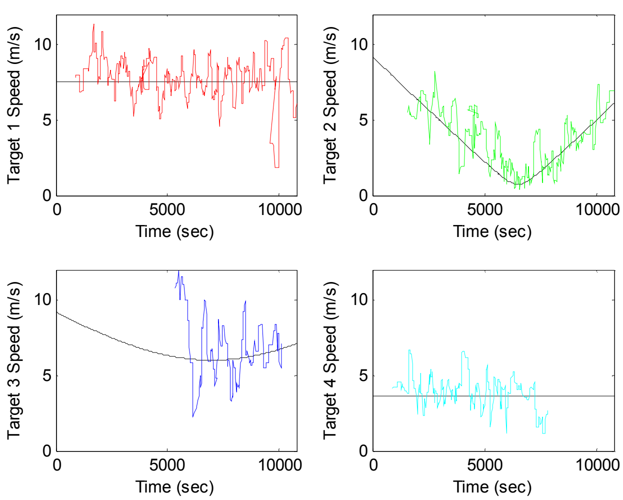

Figure 13. Tracker speed estimates for the four target's true speed (black curves).

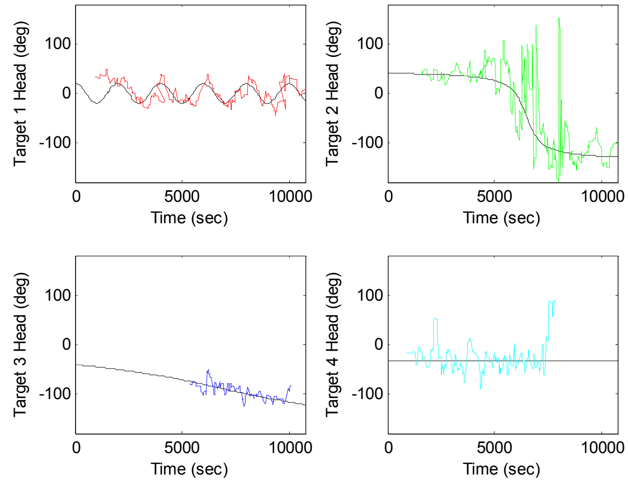

Figure 14. Tracker heading estimates for the four target's true speed (black curves).

5. Tracker Fragmentation

The SPECSweb tracker exhibits a fragmentation problem with the "Blind" data set, due to a mismatch between the assumed and actual target motion. SPECSweb uses a *nearly constant velocity* (NCV) motion model, which in most cases appropriately handles the kind of motion actual submarine targets exhibit. The inclusion of a process noise term allow for some deviations from constant velocity, i.e., in the case of discreet changes in velocity when maneuvering. However, the blind data set has one target with sinusoidal motion, and two others than manifest constant acceleration. The NCV motion model is not expected to perform very well in these cases because it is mismatched to the type of target motion in the data set.

An explanation of the fragmentation effect follows. The NCV motion model projects the target motion forward, as depicted in Figure 15 (in green). The actual motion follows a non-CV trajectory, as indicated (in red). It then becomes more likely that a false alarm contact (depicted in blue) will be the nearest (statistical) neighbor selected for data association. The true target contact can then potentially initiate a track fragment. The new fragment can persist and continue on (being fed by true contacts), or it may exist for a short time, simultaneous to the actual track.

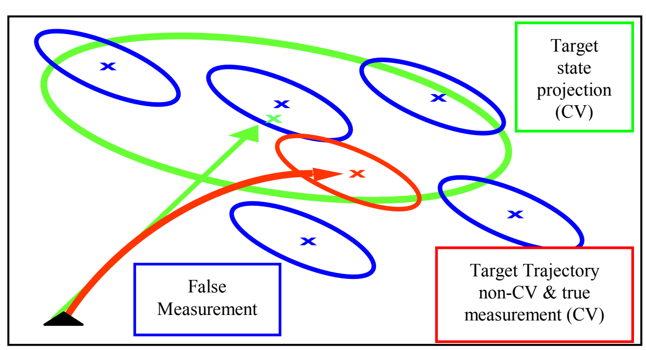

Figure 15. Fragmentation with motion model mismatch.

6. Conclusions

The SPECSweb tracking and fusion algorithm has been described. Its application to MSTWG simulated data sets shows excellent potential. The use of two thresholds has been demonstrated; the higher threshold (HTH) effectively exploits the specular echo as a cue for initiating a tracking process, and the lower threshold (LTH) for selective snippet retrieval and track update.

The results of the tracker on the TNO and ARL/UT show excellent tracking performance overall, with no false tracks being generated. It has been shown that this provides a solution to the false track generation problem of tradition single-threshold tracking approaches.

The SPECSweb tracker was successful in identifying the three "hidden" targets in the MSTWG Blind data set. Good tracking performance was obtained, with the exception of a fragmentation problem due the inaccurate assumption of constant velocity targets. Improvements in fragmentation would be obtained by incorporating a constant acceleration motion models and more sophisticated data association methods (PDA or MHT).

Future work will focus on application to other real datasets, further algorithm automation, and multistatic target classification.

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